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Process and Device for Producing Spherical
Particles from Spontaneously Reacting Liquid
Components

H. Huschka and E. Wehner

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Applicant:

Nukem GmbH, 6450 Hanau, Germany

Inventors:

Huschka, Hans, Dr., 6450 Hanau,
Germany; Wehner, Erwin, Dr.,
6078 Neu-Isenburg, Germany

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**Process and Device for Producing Spherical Particles from Spontaneously
Reacting Liquid Components**

To produce spherical particles with diameters between 50 and 2500 μm and a narrow particle size spectrum from two liquid components with substances that react spontaneously with one another, the components, driven to oscillate in phase at the same frequency by vibration, are fed to separate nozzles that are aligned so that the two jets of droplets strike one another at an angle of 10 to 120°. (31 26 854)

NUKEM GmbH
6450 Hanau 11

Process and device for producing spherical particles from spontaneously reacting liquid components

1. Process for producing spherical particles with a diameter between 50 and 2500 μm and a narrow particle size spectrum from two liquid components that consist of solutions or molten substances that react with one another within a short time after mixing, with solidification, or that contain substances in dissolved, dispersed, or emulsified form that react with one another within a short time after mixing, by having these liquid components, set into oscillation by vibration, flow out of nozzles and solidify while falling, characterized by the fact that the two liquid components to which oscillation is imparted in phase and at the same frequency by vibration are fed to separate nozzles that are aligned so that the two jets of droplets strike one another at an angle of 10 to 120°.
2. Process pursuant to Claim 1, characterized by the fact that the two jets of droplets collide at an angle of 40 to 70°.
3. Device for producing spherical particles pursuant to Claim 1 and 2, essentially consisting of two nozzles with nozzle holders, infeed lines, and a vibrator system, characterized by the fact that the nozzles (1, 2) are aligned so that the axes of the nozzles form an angle (α) of 10 to 120° and the vibrator system (3) forces the liquid components to oscillate in phase at the same frequency.
4. Device pursuant to Claim 3, characterized by the fact that the distance (a) between the two nozzles (1, 2) is 10 to 100 mm.

5. Device pursuant to Claims 3 and 4, characterized by the fact that the two nozzles (1, 2) are solidly installed in a common holder and are provided with a common vibration system.
 6. Device pursuant to Claims 3 to 5, characterized by the fact that the nozzles (1, 2) installed in a common holder are coupled to one another by a mechanism in such a way that the symmetry of an isosceles triangle is necessarily maintained when the angle between the arms of the triangle formed by the extended nozzle axes is varied.
-

NUKEM GmbH
6450 Hanau 11

Process and device for producing spherical particles from spontaneously reacting liquid components

This invention relates to a process and a device for producing spherical particles with a diameter between 50 and 2500 μm and a narrow particle size spectrum from two liquid components that consist of solutions or molten substances that react with one another and solidify within a short time after mixing, or that contain substances in dissolved, dispersed, or emulsified form that react with one another within a short time after mixing, by having these liquid components set into oscillation by vibration flow out of nozzles and solidify while falling.

Spherical particles in the size range between 50 and 2500 μm are needed and used in various sectors. Maintaining a narrow particle size spectrum and uniform roundness produces particles with uniform surface areas and volumes, which leads to precisely adjustable and calculable product characteristics. Other benefits are the absence of dust and good free-flowing properties of such products.

Because of these properties, it has been endeavored in various fields of application to produce products in the form of small spheres of equal size. Thus, it is known how to make spherical particles with diameters up to 900 μm for nuclear engineering from a uranyl nitrate solution to which hexamethylenetetramine has been added (DE-AS 1960289). For physical reactor reasons, a very narrow particle size spectrum and a precise spherical shape are necessary in that case.

A process is described in German Patent Application Exposition 2725924 for the preparation of small, spherical particles from meltable substances with drugs contained in them for the pharmaceutical industry.

A uniform particle size spectrum is necessary for this application to control the release of drug when used.

In the production of insulating window glass panes, small spherical particles of silica gel are incorporated into the frame, that are intended to absorb water of condensation between the panes. In this case, a small, uniform spherical product is needed to be able to calculate the absorptive power, and for reasons of the space available.

In all fields of use of spherical particles with narrow particle size spectrum, those that have to be prepared from components that react spontaneously with one another under normal conditions are encountered.

The procedures for producing spherical particles from components that react with one another within a short time after mixing that are known so far are not very suitable for this area of use. Thus, for example, it has been suggested to make an aqueous solution of uranyl nitrate, urea, and hexamethylenetetramine (HMTA) in such a way that it is stable for some time at temperatures below 10°, but gels quickly at temperatures above 10°C by liberating NH_3 from a thermal decomposition reaction of HMTA and precipitation of "ammonium diuranate" (ADU) from the reaction of uranyl nitrate with this ammonia (DE-AS 1960289). To produce uniformly round particles, the carefully cooled solution is forced out of a nozzle while applying a vibration in such a way that the cast stream breaks up into uniform drops, which then fall into a hot oil bath and solidify there from the reaction described, also called internal gelling. To avoid plugging of the nozzle, cooling arrangements are also found on it. In principle, therefore, a mixture of two reactants that react spontaneously with one another has to be prevented from reacting initially in this case by difficult measures, and this reaction then has to be forced by measures that are no less difficult. The freshly prepared cores have to be washed free of oil with an organic solvent, and additional organic

chemical waste is formed in the distillation bottoms from the treatment of the heat transfer fluid. An additional drawback of this process consists of the fact that the cast solution has satisfactory stability only at temperatures below the freezing point.

The processes described in DE-AS 20637020 and 1817092 for the production of UO_2 , ThO_2 , or U/ThO_2 spherical particles likewise operate with the method of internal gelling described above, and accordingly they have the same drawbacks with regard to organic chemical waste and storage life of the casting solution.

A process is described in German Patent 921564 by which slowly reacting sols are coated with a substance that can be precipitated rapidly, and are solidified by a precipitation reaction of the coating. Besides the alkali metal alginates used by way of example, an oil film is also used to separate the sol droplets from the alginate film. Both the oil film and the alginate coating have to be removed after slow solidification of the spherical particles of sol by burning them off. In this process, the sol also has to have a sufficiently slow reaction rate for gelling to avoid plugging in the nozzle or before it. Additional wastes formed from the coating layers are another drawback.

To produce spherical silica gel particles, it is also known how to mix a solution of waterglass and diluted sulfuric acid and cast it into an oil bath in a turbulent stream through a Daniell tap, with the concentration conditions being chosen so that solidification to a gel occurs only after about three seconds, so that plugging of the tap is avoided. However, spherical particles prepared by this process have a diameter spectrum from below one millimeter to more than one centimeter.

The processes described have the common characteristics and drawbacks that to produce round particles of uniform size from components dissolved or suspended in the starting solution that react with one another in a short time, the physical and chemical parameters of the process have to be harmonized with one another so that reaction, solidification, or gelling of a solution that is

already inherently reactive is prevented within the casting system. As a result of this inhibition of reaction prior to the nozzle, either a longer reaction time and with it a long falling distance has to be accepted in the gelling area, or the falling section for the drop after the nozzle, or additional process steps have to be accepted, for example to accelerate the gelling reaction. In all cases this leads to complicated processes with additional waste problems.

It was therefore the purpose of this invention to find a process and a device for producing spherical particles with a diameter between 50 and 2500 μm and a narrow particle size spectrum from two liquid components that consist of solutions or molten substances that react with one another and solidify within a short time after mixing, or that contain substance in dissolved, dispersed, or emulsified form that react with one another within a short time after mixing, by having these liquid components, set into oscillation by vibration, flow out of nozzles and solidify while dropping, without plugging of the nozzle, additional waste being formed, or steps having to be taken to slow down the reaction.

This problem is solved by the invention by the fact that the two liquid components set into oscillation in phase and at the same frequency by vibration are each fed to a separate nozzle, with the nozzles being aligned so that the two jets of droplets strike one another at an angle of 10 to 120°. The nozzles are positioned horizontally relative to one another so that the line joining them forms the base and the extensions of the nozzle axes pointing diagonally downward form the arms of an isosceles triangle marked out by the intersection of the longitudinal axes of the nozzles and the nozzles themselves. The liquid components are set into in-phase oscillation by applying a completely identical vibration, because of which they emerge from the nozzles as laterally transposed identical jets of droplets. These casting jets collide with one another at or just below the intersection of the extended axes of the nozzles with union and mixing of a droplet from each of the two jets into a larger droplet, and are thus solidified as a stream of individual drops in the following falling section by chemical reaction of the components, now combined, or by solidification of the carrier substance, into

separate spherical particles of equal size. The chemical and physical parameters of the process can be selected so that the joining, precipitation, or solidification reaction occurs as quickly as possible and in a short falling time and falling distance, without thereby causing a risk of plugging the nozzles.

To produce the particles, two casting solutions are first suitably prepared in the same solvent or in the same carrier material, each of which contains one of the reactive components. Suitable components are all substances that react with one another upon mixing with gelling, precipitation, or chemical change. Besides the customary inorganic and organic solvents, molten waxy or fatty substances are also especially suitable as carrier materials. It has proved to be advantageous for the two jets of droplets to strike one another at an angle of 40 to 70°.

The two casting solutions, each containing one of the reactive components, are designated A and B below. Essentially devices such as those described in DE-AS 27 25 849 and in DE-OS 30 35 331 are used to carry out the process. The figure shows schematically an example of embodiment of such a device. Each of the solutions A and B is held at a certain temperature in a thermostatic bath connected to one of the two nozzles. The temperature control on the one hand permits the viscosity of the casting solution to be adjusted to the desired range of less than 60 cP, preferably 10-30 cP, but on the other hand, it permits the reaction rate of the components of solution A and solution B with one another after mixing to be controlled. In addition, the temperature control can keep a melt at temperatures above the solidification point.

Therefore, it is practical for the entire system up to and including the nozzle to be under similar thermostatic control. The solutions A and B are forced out of the supply tanks separately through the two nozzles (1, 2) by gas pressure applied to them. Preferably, pressures between 0.1 and 5 bar gauge pressure are used for this. The precise flow rates are adjusted with a regulating valve between each supply tank and nozzle.

A constant harmonic vibration of at least 50 Hz is impressed on the jets emerging from the nozzles (1, 2) by a vibrator (3), which breaks the jets down into the same number of drops per second. The size of the particles that are formed depends on the frequency and the selected volume rate of flow of the emerging solutions. The nozzle diameters that result in the jet diameters have to be matched to the particle sizes required in order to achieve good drop formation. A different drop size can be set for solution A, and thus a different volume rate of flow and nozzle size, than for solution B. This will always be the case when the ratio of the reaction volumes or of the solution volumes of A and B differs from 1. On the other hand, the frequency of the two casting jets must always be kept absolutely synchronous. This is preferably achieved by exciting the two casting jets by the same vibration system. Another possibility consists of exciting the casting jets of solution A and B each with its own vibration system, but providing each system with the same amplifier signal by connecting them in parallel to the same frequency generator.

When the two nozzles (1, 2) are positioned horizontally next to one another with nozzle openings pointing diagonally downward, so that the extension of the longitudinal axes of the nozzles intersect at an angle between 10° and 120° , the jets of droplets of casting solutions A and B emerging from them collide at or just below the point of intersection of the axes. Surprisingly, a droplet of solution A always encounters a droplet of solution B at this point. The two droplets are mixed in fractions of a second into drops whose volume corresponds to the sum of the volumes of the droplets forming it. Thus, from the two casting solution jets A and B colliding with one another in a V-shape is formed a product stream that drops downward vertically with synchronous frequency from the point of combination of the casting jets. Advantageously, the distance (a) between the two nozzles (1, 2) is 10 to 100 mm.

Surprisingly, it is found in this process that the thorough mixing of each of the two droplets striking one another is so intensive that good homogenization of the product is achieved even with the shortest reaction times.

To increase throughput, several pairs of nozzles can be connected in parallel. The nozzles for components A and B can each be supplied in this case from a common supply tank. For very precise metering, however, the flow rate to each nozzle can preferably be regulated with a separate valve.

An increase of throughput with the process pursuant to the invention can be achieved by using high frequencies and a correspondingly higher volume flow rate. Particles with diameters of 1200 μm and larger are preferably produced with a frequency between 100 and 400 Hz, and particles below 500 μm with frequencies between 1000 and 2000 Hz. For example, with a frequency of 200 Hz and particle diameters of A and B of 1000 μm each, a resultant product diameter of 1260 μm can be set, which corresponds to a throughput of about 0.75 l/h.

The process of the invention will be described in detail with reference to the following examples.

Example 1:

Solution A consisted of potassium waterglass of about 28°-30° Beaumé, and solution B of approximately 10% sulfuric acid. With these concentration ratios, gelling is observed immediately after mixing. The two casting solutions are transported separately by compressed air from the supply tanks through tubes to the nozzles. These were oriented at an angle of 55° from one another, and were separated from one another by 20 mm. Just before the nozzles, the casting solutions A and B were set into synchronous oscillation at 400 Hz by an electromagnetic vibration system, so that the emerging jets were divided into 400 drops per second. About 15 mm below the horizontal line joining the nozzles, the casting jets flowing diagonally downward were combined into a product stream falling vertically. The product drops solidified while falling at room temperature through air in a section 1.5 m long, and were collected in a container as spherical gel particles. Particle diameters of solutions A and B of 800 μm each resulted in a spherical silica gel particle with a diameter of about 1010 μm . The throughput was 0.77 l/h in this case.

Examination of the particles showed an average diameter of 1007 μm with maximum deviations of 80 μm .

Example 2:

Solution A consisted of an aqueous uranyl nitrate solution with 500 g U/l and 250 g urea/l, and solution B consisted of an aqueous solution of hexamethylenetetramine (HMTA) with an HMTA concentration of 375 g/l. The two casting solutions were transported through tubes to the jets by compressed air. The nozzles were oriented at an angle of 60° from one another and were separated by 25 mm. Just before the nozzles, a synchronous oscillation at 100 Hz was imparted to the solutions. Solution A was cast with a flow rate of 7.58 ml/min and solution B at a rate of 13.82 ml/min. This forms drops with diameters of A = 1.34 mm and B = 1.64 mm, which combine about 18 mm below the nozzle horizontals into a chain of spherical "ADU" particles that solidify rapidly by gelling. The spherical gel particles fell directly into an aqueous ammonia wash solution. After washing, the gel spheres were dried and reduced and sintered under hydrogen at 1650°C.

High-density ceramic cores of UO_2 with an average diameter of 502 μm were obtained in a yield of 92%. The standard deviation was 13.2 μm . 99% of the cores thus produced had a diameter ratio ($d_{\text{max}}/d_{\text{min}}$) smaller than 1.2, and were therefore very round.

Example 3:

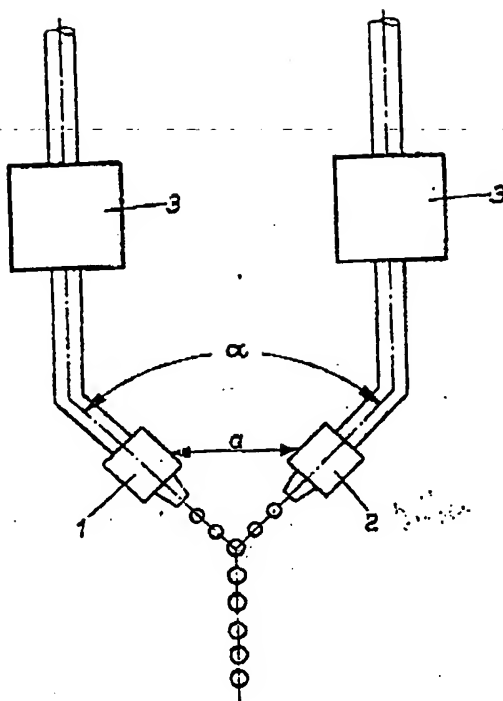
Solution A consisted of an aqueous solution with 427 g U/l (900 g $\text{UO}_2 \cdot (\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O}$, 200 g resorcinol/l, and 50 g ethylene glycol/l. Solution B consisted of a 40% formaldehyde solution. The polycondensation between resorcinol and formaldehyde was used as the solidifying reaction in this case. Solution A was thermostatted at 80°C. The two solutions were processed as in Example 2. The particles hardened throughout while falling about 2 m in air. They were dried up to 300°C in air, with the binder also carbonizing, and were then reduced and sintered under hydrogen up to 1650°C. UO_2 cores with an

average diameter of 298 μm with a standard deviation of 19.5 μm were obtained in about 90% yield.

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- ⑦1 Anmelder:
Farkas, Pierre, La Ferte Gaucher, Seine et Marne, FR

- ⑦4 Vertreter:
Geitz, H., Dr.-Ing., Pat.-Anw., 7500 Karlsruhe

- ⑦2 Erfinder:
gleich Anmelder

⑤4 Brennkraftmaschine, insbesondere Zweitaktmotor, mit einem Verdichter zum Zuführen der Verbrennungsluft

Bei der mit einem Verdichter zum Zuführen der Verbrennungsluft zu den Arbeitszylindern versehenen Brennkraftmaschine ist der Verdichter (10) mittels eines Getriebes (4, 12, 13) mit veränderbarer Übersetzung von der Brennkraftmaschine (1) angetrieben und bei dem Getriebe kann es sich um ein Umschlingungsgetriebe mit einem zwischen zwei Keilriemenscheiben (4, 13), deren wirksamer Durchmesser veränderbar ist, geführten Keilriemen (12) handeln, wobei die eine Riemenscheibe auf der Kurbelwelle der Brennkraftmaschine (1) und die andere Riemenscheibe auf der Welle des Verdichters (10) angeordnet sind. (31 26 054)

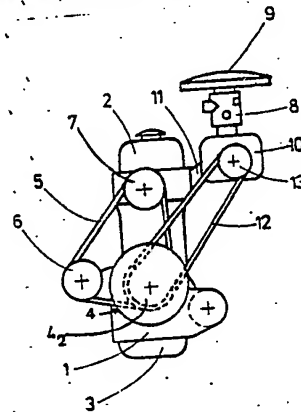


Fig.1

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Patentansprüche:

1. Brennkraftmaschine mit vergrößertem Arbeitshub, insbesondere Zweitaktmotor, mit einem Verdichter zum Zuführen der Verbrennungsluft zu den Arbeitszylindern, dadurch gekennzeichnet, daß der Verdichter (10) mittels eines Getriebes (4, 12, 13) mit veränderbarer Übersetzung von der Brennkraftmaschine (1) angetrieben wird.
2. Brennkraftmaschine nach Anspruch 1, dadurch gekennzeichnet, daß es sich bei dem Getriebe mit veränderbarer Übersetzung um ein Umschlingungsgetriebe mit einem zwischen zwei Keilriemenscheiben (4, 13), deren wirksamer Durchmesser veränderbar ist, geführten Keilriemen (12) handelt, wobei die eine Riemenscheibe auf der Kurbelwelle der Brennkraftmaschine (1) und die andere Riemenscheibe auf der Welle des Verdichters (10) angeordnet sind.
3. Brennkraftmaschine nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Einstellung des Übersetzungsverhältnisses des Getriebes (4, 12, 13) durch von einem Höhenmesser vorgegebene Meßwerte gesteuert wird.

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4. Brennkraftmaschine nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Einstellung des Übersetzungsverhältnisses des Getriebes (4, 12, 13) von einem Meßfühler gesteuert wird, der den Staudruck am Verdichter (10) mißt.

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Anmelder: Pierre Farkas
La Chapelle Moutils

La Ferte Gaucher (Seine et Marne)
Frankreich

Brennkraftmaschine, insbesondere Zweitaktmotor, mit
einem Verdichter zum Zuführen der Verbrennungsluft

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Beschreibung:

Die Erfindung bezieht sich auf eine Brennkraftmaschine mit vergrößertem Arbeitshub, insbesondere auf einen Zweitaktmotor, mit einem Verdichter zum Zuführen der Verbrennungsluft zu den Arbeitszylindern.

Bei Brennkraftmaschinen ist es bekannt, im Interesse einer erhöhten Leistungsausbeute die Füllung der Arbeitszylinder durch Zuführen mittels eines Ladegebläses, im folgenden Verdichter genannt, vorverdichteter Verbrennungsluft zu verbessern. Soweit man von dem bekannten, jedoch hinsichtlich der baulichen Maßnahmen recht kostenaufwendigen Prinzip der sogenannten Abgas-Turboaufladung absieht, werden bei derartigen Motoren die Verdichter mit Hilfe eines angepassten Getriebes von den Brennkraftmaschinen in der Art angetrieben, daß die Drehzahl des Verdichters immer proportional der Motordrehzahl ist, wodurch sich eine gleichbleibende Leistungssteigerung infolge Aufladung unabhängig von der Last ergibt.

Unbefriedigend bei derartigen Brennkraftmaschinen ist, daß sich beim Betrieb in größeren Höhen angesichts der dort anzutreffenden geringeren Dichte der Luft ein be-

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deutender Leistungsabfall ergibt. Ziel der Erfindung ist es, diesen Unzulänglichkeiten durch einfache Maßnahmen abzuhelpfen.

Gelöst ist die gestellte Erfindungsaufgabe dadurch, daß bei einer Brennkraftmaschine nach dem Oberbegriff des Patentanspruchs 1 der Verdichter mittels eines Getriebes mit veränderbarer Übersetzung von der Brennkraftmaschine angetrieben wird, so daß durch entsprechende Einstellung des Übersetzungsverhältnisses dieses Getriebes eine Anpassung der Verdichterleistung an veränderte Einsatzbedingungen vorgenommen werden kann.

Eine zweckmäßige Ausgestaltung der Erfindung besteht darin, daß es sich bei dem Getriebe mit veränderbarer Übersetzung um ein Umschlingungsgetriebe mit einem zwischen zwei Keilriemenscheiben, deren wirksamer Durchmesser veränderbar ist, geführten Keilriemen handelt, wobei die eine Riemenscheibe auf der Kurbelwelle der Brennkraftmaschine und die andere Riemenscheibe auf der Welle des Verdichters angeordnet sind.

In ebenfalls weiterer Ausgestaltung der Erfindung kann die Einstellung des Übersetzungsverhältnisses des Getriebes durch von einem Höhenmesser vorgegebene Meßwerte oder durch

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einen Meßfühler erfolgt n, der den Staudruck am Verdichter mißt.

Anhand der beigefügten Zeichnung soll nachstehend eine Ausführungsform der Erfindung beschrieben werden. In schematischen Ansichten zeigen:

Fig. 1 eine Brennkraftmaschine mit einem Lade-Verdichter in einer Frontansicht und

Fig. 2 das zwischen der Kurbelwelle der Brennkraftmaschine und dem Verdichter angeordnete Getriebe mit veränderbarer Übersetzung für sich allein in einer gegenüber Fig. 1 vergrößerten Schnittansicht.

Bei dem Ausführungsbeispiel gemäß Fig. 1 ist ein Verbrennungsmotor 1 mit einem Arbeitskolben dargestellt, der mit einer Kipphäbelabdeckung 2, einer Ölwanne 3 und einer Keilriemenscheibe 4 versehen ist, die auf dem Ende der Kurbelwelle aufgenommen ist. Über diese Keilriemenscheibe 4 und einen Keilriemen 5 wird die Keilriemenscheibe 6 einer Gleichstromlichtmaschine oder eines Wechselstromgenerators sowie die Keilriemenscheibe 7 einer Wasserpumpe und eines Ventilators angetrieben.

Der Motor nach diesem Ausführungsbeispiel besitzt einen Vergaser 8, der zwischen dem Ausgang eines Luftfilters 9 und dem Eingang eines Verdichters 10, bei dem es sich um

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ein Ladegebläse, eine Ladepumpe oder einen Kompressor handeln kann, geschaltet ist, um über eine nur schematisch angedeutete Verbindung 11 die Motorzylinder zu speisen. Obgleich bei der gezeigten Ausführungsform der Vergaser oberhalb des Verdichters 10 angeordnet ist, wäre natürlich auch eine umgekehrte Montage möglich. In diesem Fall wäre dann ein Staustromvergaser erforderlich.

Gleichfalls wäre anstelle einer mit Vergaser ausgerüsteten Brennkraftmaschine die Erfindung auch bei einer Maschine mit Brennstoffeinspritzung anwendbar.

Der Verdichter 10 wird von der Brennkraftmaschine 1 mit Hilfe eines Getriebes mit veränderbarer Übersetzung angetrieben. Im vorliegenden Falle handelt es sich dabei um ein Umschlingungsgetriebe mit einem Keilriemen 12, der zwischen zwei Keilriemenscheiben 4, 13 mit veränderbarem Durchmesser gespannt ist. Die Keilriemenscheibe 4 ist auf dem Ende der Kurbelwelle der Brennkraftmaschine 1 aufgenommen, während die Keilriemenscheibe 13 drehfest auf der Antriebswelle des Verdichters 10 sitzt.

Gemäß Fig. 2 ist auf dem Ende 14 der Kurbelwelle der Brennkraftmaschine ein mittels eines Keils 16 drehfest angeordnetes Nabenteil 15 mit einem Flanschteil 4₁ der

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Keilriemenscheib 4 drehfest und axialfest angeordnet. Der andere Flanschteil 4_2 der Keilriemenscheibe ist in Längsnuten des Nabenteils 15 axialbeweglich geführt, im übrigen aber drehfest angeordnet. Der axialen Einstellung des Flanschteils 4_2 dient ein Steuerelement 17, welches gabelförmig ausgebildet ist und über ein Kugellager 18 und eine Glocke 19 am Flanschteil 4_2 angreift.

Die auf der Welle 20 des Verdichters 10-aufgenommene Keilriemenscheibe 13 besteht ebenfalls aus zwei Flanschteilen 13_1 und 13_2 , von denen das Flanschteil 13_1 auf einem Nabenteil 21 fest, hingegen das Flanschteil 13_2 in Längsnuten des Nabenteils geführt und axialbeweglich aufgenommen sind, und zwar gegen die Wirkung einer Rückstellfeder 22.

Wenn das Flansch^{teil}/ 4_2 der Keilriemenscheibe 4 unter Einwirkung des gabelförmigen Steuerelementes 17 axial verschoben wird, ändert sich der wirksame Durchmesser der Keilriemenscheibe 4. Entsprechend gegensinnig ändert sich der Durchmesser der Keilriemenscheibe 13, wodurch sich das Übersetzungsverhältnis des Umschlingungsgetriebes ändert und mithin die Antriebsgeschwindigkeit des Verdichters 10 variiert wird.

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Das gabelförmige Steuerelement 17 kann von Hand oder automatisch über ein Stellglied in Abhängigkeit von Meßwerten, die von einem Höhenmesser oder einem Meßfühler als Meßwertgeber vorgegeben werden, gesteuert werden, wobei der Meßfühler beispielsweise den Staudruck am Verdichter mißt. Das Umschlingungsgetriebe mit veränderbarem Übersetzungsverhältnis kann auch durch einen hydraulischen oder elektrischen Antrieb ersetzt werden.

Die erfindungsgemäße Ausbildung einer Brennkraftmaschine mit einem mittels eines hinsichtlich seines Übersetzungsverhältnisses veränderbaren Getriebe zwischen der Kurbelwelle der Brennkraftmaschine und der Antriebswelle eines Lade-Verdichters ermöglicht gleichermaßen bei Vergasermotoren oder bei Einspritzmotoren eine Reduzierung des Kraftstoffverbrauchs und eine Minderung der Abgasverluste, desgleichen eine Leistungsverbesserung in großen Höhen. Eine Leistungssteigerung einer derartigen Brennkraftmaschine kann auch in Abhängigkeit von geforderten Leistungsspitzen erreicht werden, wenn in Abhängigkeit vom Auftreten solcher Leistungsanforderungen die Einstellung des Übersetzungsverhältnisses des Getriebes zwischen der Kurbelwelle der Brennkraftmaschine und der Antriebswelle des Verdichters erfolgt.

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Bei dem einzusetzenden Verdichter kann es sich um herkömmliche Ladegebläse, eine Ladepumpe oder auch einen Kompressor handeln, wobei für langsam drehende Motoren insbesondere Ladepumpen, hingegen für schnell drehende Motoren, wie Flugzeugmotoren oder auch Automobilmotoren, insbesondere Ladekompressoren in Betracht kommen.

Möglich ist es auch im Rahmen der Erfindung, zwei hintereinander geschaltete Verdichter einzusetzen, wobei der erste vorrangig geschaltete Verdichter ein Kreiselverdichter und der zweite Verdichter eine Ladepumpe sein können, so daß der Kreiselverdichter die Verbrennungsluft der Ladepumpe bereits mit einer Vorverdichtung zuführt, die beispielsweise beim Einsatz solcher Einrichtungen in großen Höhen etwa dem atmosphärischen Druck bei der Höhe Null entspricht.

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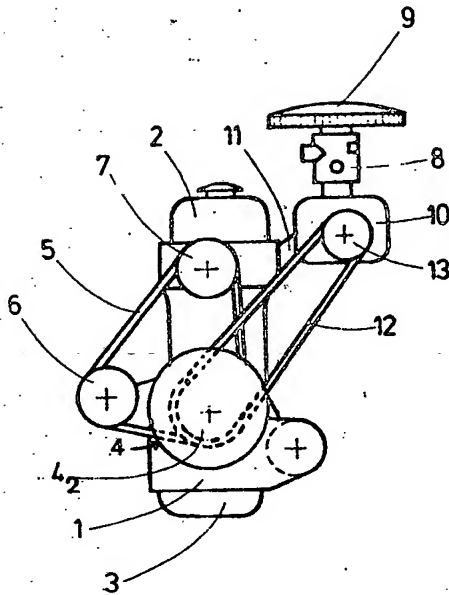


Fig. 1

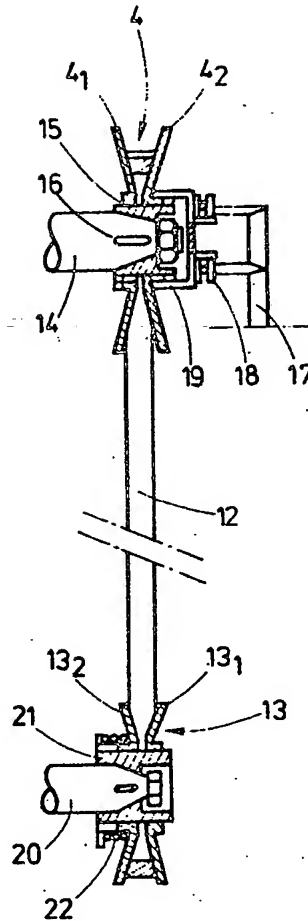


Fig. 2